

small fields and challenges in multicentre comparison of gamma analysis for complex dose distributions. Overall, the IAEA supports developments of various audit tools for radiotherapy with the audit scope corresponding to the evolving complexity of radiotherapy technology, in order to verify radiotherapy physics practices and improve the quality of treatments delivered to cancer patients in participating countries.

### Symposium: Strategies for treatment planning

#### SP-0030

#### Comparisons of treatment planning with photons and protons

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This presentation will focus on the main differences between the radiotherapy treatment planning with photons and protons. An important issue in all treatment planning is the dosimetric uncertainties and margins to account for these. Compared to photons, protons have additional sources of uncertainties that should be analysed and understood. Insufficient quantification of margins can have more serious consequences in proton therapy than is the case for photons. The main advantage of proton beams is the finite range and sharp distal dose fall off in depth, an advantage that often is a contradiction in the sense that the range uncertainty limits the use of this advantage. A second advantage is the ability to, with every single field, give the target volume a higher dose than the surrounding tissue. The sources of range uncertainties are caused by the patient variations in anatomy and the uncertainties in the conversion of CT numbers to tissues with the correct proton interaction properties. The handling of range uncertainties play a critical role in proton planning and has an impact on the entire treatment planning process that differs from photons.

The generic PTV margin recipes used in photon planning, are not adequate in proton planning. Primarily, this is used to account for lateral beam uncertainties. In proton planning, two margins have to be considered, the lateral and the margin in depth i.e. range uncertainty. In principle, these two margins arises from different physical processes. According to ICRU 78 [1] the PTVs are recommended to be used in proton planning for dose reporting purposes. Additional volumes with beam specific margins, have to be used to account for uncertainties in range. Paganetti has suggested margin recipes that is widely used in proton planning [2].

Consequently, the range uncertainty also has an influence on the selection of beam and their entry angles. In this phase of the treatment planning process, proton planning emphasizes other considerations than photons. Robust planning has the potential of mitigate the impact of range uncertainties, aiming for a robust beam path i.e. heterogeneous geometry along the beam path. Likewise, the robustness should be considered during the optimization as well as during the treatment plan evaluation and the comparison with a photon treatment plan to choose the best treatment plan.

The contents of this presentation are based on experiences from the start-up of the first Scandinavian Proton Centre, Skandionkliniken, where the first patients were treated in late august 2015. Nearly four years before that, in January 2012, we started the Proton School in order to prepare for the clinical start and to train a group of medical physicists, dosimetrists and radiation oncologists in proton planning [3,4]. Thinking protons instead of photons has been the greatest challenge for the group as a whole. *How do we achieve the best plan?* This includes selecting robust beam angles and thinking about what the protons interact with on its way to the target volume. Discussions about target volumes has been frequent, as the use of them. Delineation is a major issue, not only for CTV/PTV but for other structures the protons might interact with in its beam path,

as well as optimisation structures to provide the best treatment plan.

#### References

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#### SP-0031

#### When to re-plan: a practical perspective

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Anatomical changes are important issue during radiotherapy because they could potentially lead to inadequate dose distribution to target and organs at risk (OAR). Radiation induced complications have a significant adverse impact on health-related quality of life. To minimize the risk adaptive radiotherapy (ART) has become state of art of modern radiotherapy. In clinical practice ART is expressed mostly by Image-Guided Radiation Therapy (IGRT) and re-planning, the last is very individualized but should be more unified. Clear guidelines are therefore needed to determine the timing of re-planning, and an increasing amount of information needs to be acquainted, transferred and stored.

There are several indications that anatomic changes are more pronounced in the first half of treatment, and therefore repeated imaging and replanning should be performed in this first time period. The parotid gland was the most studied OAR and showed the largest volume changes during radiotherapy (26% average volume decrease). The average number of radiation fractions delivered between baseline and re-planning CT scans was 15 ( $\pm 5$ ) fractions which equals 21 ( $\pm 8$ ) days. It is also well established in the Head and neck (H&N) area that, because of i.e. weight loss and/or tumor shrinkage especially in more advanced stages of cancer (T3/T4, large N+), re-planning improves relapse-free survival and significantly alleviated the late effects. In many dosimetric studies without replanning during treatment, the doses to normal structures were significantly increased and doses to target volume significantly decreased. According to literature replanning frequency increases also with smaller PTV margins.

To answer the question „When to re-plan?“ we need to know which sites would most benefit. In regard to literature studies it seems that re-plan would be the most beneficial for tumors of the biggest volume or the nearest proximity of the OAR's. Still it does not explain „when“ should we perform it. Despite of the great amount of reports and analysis further research are needed.

#### SP-0032

#### Fully automated treatment planning: benefits and potential pitfalls

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**Purpose/Objective:** Labor-intensive procedures, such as adaptive radiotherapy, result in an increased workload in the treatment planning department, which can be reduced by introducing fully automated treatment planning. The benefits of automated planning are many: reduction of workload, increased workflow efficiency, and reduction of plan variability. However, a potential pitfall could be loss of